Fire and Fuel

Introduction

Fire hazard rating is a relative measure of how virulently a wildfire might burn under the 90 percentile weather conditions that occur from April through July. It is a relative measure from site to site and from pretreatment to post treatment. It is a good indicator of how effectively and safely fire suppression crews can attack a wildfire and bring it under control.

For projects associated with GFFP the fire hazard rating is derived by accumulating hazard points associated with canopy closure, tree stems per acre, height to the bottom of the live crown, dead & down fuel loading, slope steepness, and aspect. While we cannot affect a change in slope steepness or aspect, their effects on fire behavior may influence how much we attempt to reduce other factors.

Another assessment method required of the Forest Service nationally is called the Fire Regime Condition Class rating. The Fire Regime indicates how often wildfires burned across this part of the landscape and with what level of severity. The plants and animals that inhabit this area have come to depend on that fire regime to maintain ecosystem balance. The condition class of an area indicates how far from historical norms the area has departed because the fire regime has been disrupted. In many cases, it is no longer practical to return an area to its naturally occurring fire regime and condition class, but the assessment is still valuable in determining a close-fitting proposed action.

One of the fuel treatment objectives for this project is to reduce the probability of crown fire initiation. This is achieved by reducing the crown bulk density (the volume of fuel available in treetops) throughout the sites, by increasing the effective crown base height (the height at which tree branches can be ignited by ground fire), and by reducing the expected flame length (the heat emitted by a ground fire).

Another fuel treatment objective is to reduce the capability of the sites to sustain a crown fire should one develop. This is achieved by reducing the percent of canopy closure as well as the tactics identified to reduce crown fire initiation.

Another fuel treatment objective is to reduce the number of firebrands that could ignite spot fires. This can also be achieved by reducing the crown bulk density, by increasing the effective crown base height, and by reducing the expected flame length.

Another fuel treatment objective is to reduce the distance at which firebrands would be expected to ignite spot fires. This can be achieved by reducing the number of treetops that would burn simultaneously if ignited by ground fire. In turn one must reduce the crown bulk density and canopy closure.

The treatments proposed would be expected to maintain these objectives for approximately 20 years by periodic prescribed burning without additional thinning treatments.

Periodic prescribed burning can reduce the expected flame lengths by maintaining a low dead and down fuel loading. To facilitate prescribed burning canopy closures must be reduced. Also to reduce the fire hazard across this project area canopy closure must be reduced and crown base height must be raised. Thinning reduces canopy closure, crown bulk density, and can increase the effective crown base height.

A final fuel treatment objective is to bring the project area closer to the natural historic fire regime of vegetation characteristics, fuel composition, fire frequency, severity and pattern. This can be achieved by thinning followed by prescribed burning at appropriate intervals.

Regulatory Framework

Many desired future condition values for forest structure and composition come directly from the Forest Plan (USDA Forest Service 1996, Reynolds 2004.). The area was historically dependent on frequent low-intensity fires. Fire suppression has successfully excluded these historic fire intervals.

Analysis Methods

Assumptions

Areas immediately adjacent to communities and particularly areas upwind of communities would ideally have a Low wildfire hazard rating.

Dead & down fuel loading directly effects flame length and duration. The longer the flame length and duration the more difficult it is to bring a fire under control. Also the longer the flame length and duration, the more likely a fire is able to transition into a crown fire. Prescribed burning reduces the amount of dead & down fuel loading and so the expected flame length and duration.

Height to the bottom of live crown directly effects how easily a fire “torches” trees producing firebrands, as well as, how easily a fire transitions into a crown fire. Number of tree stems per acre also affects how easily a fire is able to transition into a crown fire. Thinning from below increases height to bottom of live crown, decreases the number of stems per acre, decreases canopy closure, and so reduces the ease with which a fire can “torch” trees, produce firebrands, as well as, the ease with which it transitions to a crown fire.

By containing and accumulating heat below the crown layer, canopy closure directly effects how easily a fire is able to transition into a crown fire. It can prevent necessary heat dispersal. Canopy closure also affects how easily a crown fire can sustain itself and spread as a crown fire. Thinning from below reduces canopy closure, heat accumulation below the crown and so the ease with which a fire can transition to a crown fire. It also reduces the ease with which a fire can "torch" trees and produce firebrands, as well as the height to which firebrands are lofted and the distance at which spot fires would be expected to occur. Uneven age thinning reduces canopy closure and stems per acre, but does not increase height to bottom of live crown as effectively as thinning from below. Uneven age thinning does result in greater age class diversity.

During severe weather conditions heat could accumulate under canopy closures greater than 50% and result in tree-torching and pockets of trees torching with multiple spot fire ignitions. Although existing fire behavior programs can not model this, fire from a relatively light fuel load has been frequently observed to climb the trunks of trees during drought conditions and torch the tree tops even though ground fire flame lengths have been less than 3'. Only a more open canopy and reduced crown bulk density can mitigate this fire behavior problem.

Flame length is a reliable indicator of fire intensity and probable tree mortality. It can also indicate how effectively action alternatives meet other fire-related objectives. "Critical flame length" is the threshold distance where ground fire can move into the canopy of a stand.

The fire suppression forces making the initial attack on wildfires that may occur within the project area are wildland fire engines. These initial attack forces can generally take effective suppression action against wildfires with flame lengths less than 4 feet. Fires with flame lengths longer than 4 feet generally require bulldozers and sometimes air tankers. It might even require an indirect-attack strategy, which requires considerably more distance and time than can be afforded this close to developments.

Some sites within the project area may retain a higher fire hazard condition because of important wildlife considerations or because they are inaccessible by mechanized equipment. This may require further hazard reduction in the surrounding sites to mitigate the higher hazard condition of un-thinned sites.

Models

Both the Fuel Management Analyst (version 3+) and BEHAVE 3 programs were used to model fire behavior and fire effects for this analysis. The Fuel Management Analyst program is more sensitive to varying crown base height and crown bulk density. The BEHAVE 3 model can provide a better fitting ground fuel model and is sensitive to herbaceous fuel moisture. Fire behavior analysis is most accurate when multiple models are compared in light of their unique limitations. Fuel models must be selected for their fire behavior characteristics, not necessarily for their vegetative descriptors.

Weather inputs cannot be used to measure how much safer an area will become after treatment, but they are valuable in comparing relative fire hazard ratings across sites and relative to pre- and post-treatments effects. The fuel moisture and weather characteristics used to model the fire effects are the same as those used for Flagstaff Center projects since the year 2000, in order to maintain consistency when comparing fire hazard. Many of these conditions can occur throughout the year, but occur locally most often from April through early July.

1-Hour Fuel Moisture: 2%
10-Hour Moisture: 3%
100-Hour Moisture: 6%
20-Foot Wind Speed: 20mph
Air Temperature: 85^0F

Methodologies used

Field data including percent of canopy closure, height to bottom of live-crown, tree height, tree diameter, dead fuel loading, and tree stems per acre was collected in 2005 and 2006 by fuels crews. Fire regimes and condition classes were assessed during the field surveys and using LANDFIRE data for this project.

Brown's Transect Dead and Down Fuel Inventories were taken to determine dead fuel loading in most sites. In some cases, the Photo Series for quantifying Forest Residues in the Southwestern Region were used to estimate dead and down fuel loading.

Existing Conditions

The fire hazard of the existing condition across the sites surveyed to date is listed in the table below (totals may include some private and state land);

Table 1 – Existing Condition acres by Fire Hazard Rating

Extreme	Very High	High	Moderate	Low
31 acres	985 acres	3,703 acres	5,815 acres	1126 acres

Within some sites of the project area, the higher fire hazards are driven by all six of the hazard factors listed above in the introduction. While in other sites the higher fire hazard is derived from spikes in 2 or 3 of the above criteria (most often crown closure, stems per acre, and crown base height). Dead and down fuel loads were severe in only a handful of sites. However, in some sites substantial tree mortality, stems per acre, canopy closures, or crown base height alone drove the fire hazard beyond a desirable level for a wildland urban interface.

The existing fire hazard makes it very difficult for initial attack forces to control a wildfire starting in some parts of the project area under severe weather conditions that occur in April, May, June, September, and October.

Table 2, Existing Condition, Expected Flame Length

Expected Flame Length Across project area by Fire Hazard Rating				
Extreme	Very High	High	Moderate	Low
Flame Length 6.0’	Flame Length 5.0’	Flame Length 4.5’ – 5.5’	Flame Length 3.5’ - 5’	Flame Length 2.5’

The modeling indicated a high occurrence of wildfire induced tree mortality (71 to98 percent) among trees 8” to 26” diameter at breast height (dbh). Critical flame lengths are the threshold distances where ground fire can move into the canopy of a stand. Average critical flame length for tree torching and transitioning to a crown fire is relatively low (2.5’ –10’). The expected ground fire flame lengths ranged from 1.2’ to 6’.

The current fuel conditions would likely generate dangerous fire behavior and undesirable fire effects when a wildfire occurs. The modeling indicated considerable torching and spot-fires as much as a one half mile a head of an intense fire in some sites within the project area. Although it would be difficult to initiate a crown fire within many sites, once initiated or if carried in from a neighboring area, many sites had sufficient crown bulk density coupled with sufficient canopy closure to sustain a crown fire and spread it through other sites. Initial attack forces would have difficulty in controlling a wildfire occurring in this area under severe weather conditions. The forest condition after a high intensity wildfire would not meet management direction in the Forest Plan for a variety of resources.

The project area is a critical watershed to the communities of Timberline and Doney Park. The project area also abuts a buried waterline (inner basin to Flagstaff Reservoir) that is critical to the city of Flagstaff. A large wildfire could reduce the hydrological function of the watershed, as well as result in erosion that undermines the critical waterline.

The majority of the project area, approximately 95%, is Fire Regime I, where a fire recurrence of less than 35 years with a low percentage of over story replacement would be expected under historical conditions. Approximately 2% of the project area is Fire Regime II, where a fire recurrence of less than 35 years with a high percentage of over story replacement would be expected under historical conditions. Areas that were historically Fire Regime II are located in the Northwest portion of the project area where an arid mixed-conifer vegetation type is found. The remaining 3% of the project area is Fire Regime V, where a fire recurrence of around 200 years with a high percentage of over story replacement would be expected even under historical conditions. The portion of the project area that is Fire Regime V was historically Pinyon pine and juniper and is located in the Eastern and Southeastern portions of the project area. Site assessments indicate that the majority of these areas have transitioned to ponderosa pine.

The only exception is the southeast slope of the area referred to as 89 Mesa, which has remained pinyon-juniper vegetation type.

95% of the project is in Condition Class 3 due to a lack of fire occurrence (a severe departure from the natural historical regime of vegetation characteristics, fuel composition, fire frequency, severity and pattern). The remaining 5% of the project is in Condition Class 2 (a moderate departure from the natural historic regime of vegetation characteristics, fuel composition, fire frequency, severity and pattern). A wildfire occurring under the existing Condition Classes of 2 and 3 would result in more severe effects than should occur for the natural Fire Regime. However, a significant number of sites would receive an improved condition class rating once prescribed fire was reintroduced, since the vegetation characteristics are within the historical range of variability. Other sites would receive an improved condition class rating after thinning and prescribed burning, since the "late-open" sites have filled-in to become "mid-closed" sites.

Table 3, Existing Condition, Fire Regime and Condition Class

Fire Regime 1: Frequent Fires (0-35 years), surface burn severity		
Condition Class 1	Condition Class 2	Condition Class 3
0	0	11214Acres

Fire Regime II: Frequent Fires (0 – 35 years), high burn severity		
Condition Class 1	Condition Class 2	Condition Class 3
0	282 Acres	0

Fire Regime V: Infrequent Fires (200+ years), high burn severity		
Condition Class 1	Condition Class 2	Condition Class 3
0	331 Acres	0

The Pinion/Juniper vegetation type within the project area (located on the east facing slope of 89 Mesa) contains a high number of dead standing Pinion trees. This area has a heavy dead and down fuel load. Due to the recent "bug-kill" it also has a heavier load of dead standing fuel. It has a moderate canopy closure, low crown base-height, and a lower average tree height. These factors result in fire hazard ratings of moderate to high.

However, the fine fuel component (grasses and long-needles) which allows a wildfire to ignite easily and spread rapidly is generally absent from this area of Pinion Pinion/Juniper. Needles are short and the litter layer is compact and discontinuous. Where the standing and down fuel load is greatest grasses are generally absent, even after the prolific grass production of 2005.

Wildfires occurring in this area of Pinion/Juniper can be expected to spread slowly in all but the most severe fire weather. They would be expected to burn intensely with short-range spotting and a slower spread rate than the Ponderosa Pine and even the pine/oak woodlands.

Direct and Indirect Effects

No Action

No Action does not address the fuel treatment objectives of this project. The existing fire hazard makes it difficult for initial attack forces to control a wildfire starting in many parts of the project area under severe weather conditions that occur in April through July.

When a wildfire occurs expected flame lengths would exceed 4 feet in many sites, making it difficult and unsafe for initial attack crews to control a wildfire occurring under modeled conditions. The critical flame lengths (treetop ignition) commonly range 6'-12'. Many of the sampled sites had two to three times the crown bulk density necessary to sustain a crown fire. Canopy closure exceeded 50% in many sites and closed-in to 65+% canopy cover over the course of 20 years.

Mortality of Ponderosa pine trees 8-14" diameter at breast height (dbh) would range as high as 99%. Ponderosa pine trees 16" dbh and greater could suffer mortality rates as high as 71%. Mortality of oak trees 10" diameter at root crown (drc) and greater would be expected to reach 98% in most sites.

The indirect effects of not taking action would allow the fire hazard to worsen over time as vegetation grows and fuel accumulates. Many of the sites currently rated with a Low or Moderate fire hazard rating would develop conditions that result in a higher hazard rating. Those sites must receive prescribed burning to maintain their acceptably low hazard rating. Some sites require thinning as well as burning to maintain their low rating over the next 20 years.

Competition between trees for moisture, nutrients, and sunlight would continue resulting in decreased tree vigor, increased susceptibility to infestation, disease and then mortality. Those trees that die, further increase the fuel load, the fire hazard, and increase the risk of successive attacks on remaining trees. The indirect effect may be the loss of habitat and wildfire damage to private property in the vicinity of the project.

Alternative 1

The fire hazard ratings after implementation of Alternative 1 are listed in Table 4. Some acres are still rated with a High, Very High, and Extreme hazard rating. These areas have been reduced from a higher rating only to High because they are in areas that are either inaccessible, which limits thinning opportunities, or they may have been deferred to meet certain wildlife habitat and watershed needs.

Table 4 – Alternative 1 Post-treatment acres by Fire Hazard Rating

Extreme	Very High	High	Moderate	Low
17 Acres	406 Acres	916 Acres	4,978 Acres	5,510 Acres

Table 5 – Alternative 2 Post-treatment acres by Fire Hazard Rating

Extreme	Very High	High	Moderate	Low
17 Acres	406 Acres	961 Acres	7,144 Acres	3,299Acres

Comparison of Alternatives 1&2 show that the fire hazard ratings increased in Alternative 2 by 45 acres in high, 2,166 acres in moderate and decreased by 2,211acres in the low category.

Table 6 – Alternatives 1&2 Post-treatment acres by Fire Regime and Condition Class

Fire Regime 1: Frequent Fires (0-35 years), surface burn severity		
Condition Class 1	Condition Class 2	Condition Class 3
0	9081 Acres	2121 Acres

Fire Regime II: Frequent Fires (0 – 35 years), high burn severity		
Condition Class 1	Condition Class 2	Condition Class 3
0		556 Acres

Fire Regime V: Infrequent Fires (200+ years), high burn severity		
Condition Class 1	Condition Class 2	Condition Class 3
0		69 Acres

Both Alternative 1&2 address the purpose and need by reducing the crown bulk density (thinning), reducing the canopy closure (thinning), increasing the effective crown base height in most sites (thinning and prescribed burning), reducing expected flame length (prescribed burning), and reducing the number and shortening the distance at which spot fires would be expected to occur (thinning and prescribed burning). However, Alternative 1 places an additional 2,248 acres in a low fuel hazard classification as compared to Alternative 2. From a fuel hazard reduction standpoint alternative 1 does more to achieve the fuel risk reduction objective than Alternative 2. ,Although Alternative 1 reduces the fire hazard to lower classes Alternative 2 still meets the project goals and objectives, because the fuel hazard has still been reduced on the project area, and overall goals for community protection and resource protection are still improved over the no action alternative. The Fire regime and condition classes remain common to both alternatives and did not change.

Alternative 1 proposes to thin and prescribe burn 6,815 acres that are currently rated as Moderate fire hazard. 5,510 of these acres would reach a Low fire hazard rating after treatment. The balance of these acres would have the characteristics that generate difficult fire behavior improved, but would not qualify for a lower fire hazard rating after treatment. Alternative 2 proposes to thin and prescribe burn 6,815 acres that are currently rated as Moderate fire hazard. 3,845 of these acres would reach a Low fire hazard rating after treatment

Alternatives 1&2 also propose to lightly thin and prescribe burn 1,126 acres that are currently rated as Low fire hazard. Although these acres already have a Low fire hazard rating, those characteristics that generate difficult fire behavior would be improved still further. Without the proposed thinning, stand characteristics changing over 20 years would cause undesirable fire behavior within the urban interface.

Common to both Alternatives

As displayed by Tables 7 and 8, modeling did not show significant changes between alternatives based on the sampled sites; however fire behavior and fire effects will have considerable differences in treatment types. Alternative 1 would reduce fire behavior and effects less than Alternative 2 but as stated Alternative 2 still meets project goals of fuels reduction and reestablishing ecosystem balance.

Areas receiving light mechanical and hand thinning, flame lengths after treatment would be expected to range between 1.5 and 4 feet, making initial attack of a wildfire occurring under modeled conditions safe and effective. The critical flame lengths (treetop ignition) would range between 3'-8'. The sampled sites would have a crown bulk density of 0.0031 to 0.0064 lbs/Ft^3. This is still high enough to sustain a crown fire.

In areas receiving mechanical thinning, flame lengths after treatment would be expected to range between 0.5 and 3 feet, making initial attack of a wildfire occurring under modeled conditions safe and effective. The critical flame lengths (treetop ignition) would range between 11'-15'. The sampled sites would have a crown bulk density of 0.0021 to 0.0024 lbs/Ft^3. This in conjunction with the canopy openness is not to sustain a crown fire.

In areas that receive prescribed burning only, flame lengths after treatment would be expected to range between 1 and 4 feet, making initial attack of a wildfire occurring under modeled conditions safer and more effective. The critical flame lengths (treetop ignition) would range between 3 -7'. The sampled sites would have a crown bulk density of 0.0014 to 0.0025 lbs/Ft^3. Characteristics necessary to propagate a crown fire will vary across these stands. Stands with canopy cover less than 40% probably will not, while stands with greater canopy percents and crown bulk densities will sustain crown fire behavior.

Prescribed burning would be relatively easy to execute and maintain. Should a wildfire occur after this treatment it is unlikely to exceed state air quality standards. Wildfire-induced mortality of Ponderosa pine trees 8-14" diameter at breast height (dbh) would not be expected to exceed 31%. Wildfire mortality of Ponderosa pine trees 16" dbh and greater would not likely exceed 9%. Wildfire mortality of oak trees 10" diameter at root crown (drc) could reach 41%, but would not be expected to exceed 19%.

In areas treated for restoration of mountain meadows and grasslands flame lengths after treatment would be expected to range between 0.5 and 3 feet, making initial attack of a wildfire occurring under modeled conditions safe and effective. The critical flame lengths (treetop ignition) would range between 11'-15'. The sampled sites would have a crown bulk density of 0.0014 to 0.0026 lbs/Ft^3. These areas would not be able to sustain a crown fire. Without periodic prescribed burning, trees would begin to reinvade these areas over the course of 20 years.

Prescribed burning would be easy to execute and maintain. Should a wildfire occur after this treatment it is unlikely to exceed state air quality standards.

Common to Both Alternatives an indirect effect of Alternatives 1&2 would be to maintain this suite of fuel treatment objectives for approximately 20 years through periodic prescribed burning and without additional thinning. Alternatives 1&2 would result in a short-term increase in wildfire hazard potential while treatments are occurring. While the proposed thinning reduces crown fire ladders, canopy closure, and crown loading, the thinning slash will usually be piled on site increasing the dead & down fuel loading until the piles are burned within prescription. Until the material composing these piles dries out they do not pose a significant hazard. These piles will be burned soon after they dry out. By timing thinning activities and piling activities so that the slash piles do not pose a hazard for more than a few months, this short term increase in fuel hazard is offset by a long-term decrease in wildfire hazard.

Table 7, **Probability of Wildfire Induced Mortality; Pre and Post Treatment, by Treatment Type. Based on averages of sampled sites**

Tree Species and Dbh	Treatment Type	Using BEHAVE3		Using Fuel Mgt Analyst	
		Alternative 1	Alternative 2	Alternative 1	Alternative 2
Ponderosa Pine Up to 8" dbh	Existing Condition	99%	99%	99%	99%
	Resource Emphasis	35%	40%	39%	40%
	Fuel Emphasis	35% - 99%	35% - 99%	64%	67%
	12" Treatment			20%	20%
	Burn Only	35% - 99%	35% - 99%	58%	58%
	MSO PAC	35%	35%	36%	36%
Ponderosa Pine 10" dbh	Existing Condition	99%	99%	99%	99%
	Resource Emphasis	25%	32%	27%	30%
	Fuel Emphasis	25% - 99%	25% - 99%	35%	37%
	12" Treatment				20%
	Burn Only	25% - 99%	25% - 99%	29%	29%
	MSO PAC	25%	25%	28%	28%
Ponderosa Pine 12" dbh	Existing Condition	98%	98%	98%	98%
	Resource Emphasis	19%	22%	20%	27%
	Fuel Emphasis	19% - 98%	19% - 98%	25%	22%
	12" Treatment	19% - 98%	19% - 98%	25%	25%
	Burn Only	19% - 98%	19% - 98%	20%	20%
	MSO PAC	19%	19%	19%	19%
Ponderosa Pine 14" dbh	Existing Condition	97%	97%	77%	77%
	Resource Emphasis	14%	17%	15%	18%
	Fuel Emphasis	14% - 97%	14% - 97%	22%	26%
	12" Treatment				
	Burn Only	14% - 97%	14% - 97%	15%	15%
	MSO PAC	14%	14%	15%	15%
Ponderosa Pine 16+" dbh	Existing Condition	96%	96%	86%	86%
	Resource Emphasis	11%	13%	10%	13%
	Fuel Emphasis	11% - 96 %	11% - 96 %	6%	9%
	12" Treatment				
	Burn Only	11% - 96 %	11% - 96 %	5%	5%
	MSO PAC	11%	11%	12%	12%
Oak 10+" drc	Existing Condition	99%	99%	98%	98%
	Resource Emphasis	27%	31%	31%	37%
	Fuel Emphasis	41%	41%	60%	60%
	12" Treatment				
	Burn Only	41%	41%	40%	40%
	MSO PAC	27%	27%	40%	40%

Table 8, Comparison of Fire Behavior Characteristics; Pre and Post Treatment, by Treatment Type, Based on averages of sampled sites.

Fire Behavior Characteristic	Treatment Type	Using BEHAVE3		Using Fuel Mgt Analyst	
		Alternative 1	Alternative 2	Alternative 1	Alternative 2
Crown Bulk Density (lbs/Ft3)	Existing Condition	NA	NA	0.0083 lbs/Ft3	0.0083 lbs/Ft3
	Resource Emphasis	NA	NA	0.0026 lbs/Ft3	0.0029 lbs/Ft3
	Fuel Emphasis	NA	NA	0.0188 lbs/Ft3	0.0113 lbs/Ft3
	12" Treatment	NA	NA	n/a	n/a
	Burn Only	NA	NA	0.0032 lbs/Ft3	0.0032 lbs/Ft3
	MSO PAC	NA	NA	0.0161 lbs/Ft3	0.0161 lbs/Ft3
Expected Flame Length (Feet)	Existing Condition	3' - 18'	3' - 18'	5'	5'
	Resource Emphasis	2' - 4'	2' - 4'	3'	3'
	Fuel Emphasis	2' - 5'	2' - 5'	3'	3'
	12" Treatment	2' - 5'	2' - 5'	3'	3'
	Burn Only	2' - 5'	2' - 5'	3'	3'
	MSO PAC	2' - 4'	2' - 4'	3'	3'
Critical Flame Lentgh (Feet)	Existing Condition	3' - 7'	3' - 7'	6'	6'
	Resource Emphasis	7' - 15'	7' - 15'	8'	10'
	Fuel Emphasis	5' - 7'	5' - 7'	11'	7'
	12" Treatment	5' - 7'	5' - 7'	6'	6'
	Burn Only	4' - 7'	4' - 7'	6'	6'
	MSO PAC	7' - 15'	7' - 15'	8'	8'
Expected Rate of Spread (Chains/Hr)	Existing Condition	3 - 65 ch/hr	3 - 65 ch/hr	33 ch/hr	39 ch/hr
	Resource Emphasis	3 - 5 ch/hr	3 - 5 ch/hr	6 ch/hr	10 ch/hr
	Fuel Emphasis	3 - 18 ch/hr	3 - 18 ch/hr	8 ch/hr	14 ch/hr
	12" Treatment	3 - 18 ch/hr	3 - 18 ch/hr	6 ch/hr	6 ch/hr
	Burn Only	3 - 18 ch/hr	3 - 18 ch/hr	6 ch/hr	6 ch/hr
	MSO PAC	3 - 5 ch/hr	3 - 5 ch/hr	6 ch/hr	6 ch/hr

Cumulative Effects

The analysis area for cumulative effects includes the area covered by the 300,000 acre + GFFP area and other non-GFFP projects within that boundary. Additionally, specific effects are considered when looking at the adjacent Eastside and Ft. Valley projects.

No Action

A cumulative effect of the no action alternative is an increase the number of acres of national forest that are vulnerable to severe fire effects. The vegetation type across the project area requires periodic fire to remain balanced. Fuel conditions have reached a point where fire effects are more severe than desired and more severe than would naturally occur. The fire hazard and fuel profile increases with time as the vegetation grows and dies.

Another cumulative effect of the no action alternative increases the possibility that a wildfire can get established and burn with sufficient intensity to exceed the capability of emergency response personnel. Wildfires in the wild-land/urban interface place particularly high demands on emergency response personnel. Such a fire threatens multiple structures and multiple groups of people in a very short span of time. Firefighting resources must be deployed to protect the people and properties that lie in the fire's path, thus leaving fewer personnel to actually bring the fire under control. This generally results in larger wildfires and greater resource damage to the national forest.

A treatment within this project does not eliminate the chance of a crown fire, but greatly reduce the chance of a crown fire initiating. By leaving a large area like Jack Smith Schultz untreated, we increase the risk of a crown fire starting and spreading as a crown fire through an adjacent area that has been treated.

Finally, (no action) leaves most of the area in Condition Class 3 (a severe departure from the natural historical regime of vegetation characteristics, fuel composition, fire frequency, severity and pattern). As time passes, the entire project area would transition to a Condition Class III and further result in destructive wildfires more severe than the area's historic fire regime.

Common to both Alternatives

The prevailing winds for this project area are out of the southwest and accelerate through Schultz Pass. The area analyzed for the cumulative fire effects of this project includes those projects that are south, east and west, of the project boundary. It constitutes most of the forested land subject to the prevailing winds driving a wildfire into the communities of Doney Park and Timberline.

The time period analyzed for the cumulative fire effects of this project includes a twenty-five year period from 1996 to 2028. Prior to that time the only activities in the area that affected the fire hazard were aggressive fire suppression and the continuing growth of forest vegetation. After 2028 models indicate that the continuing growth of forest vegetation will cause the fire hazard to approach current conditions in many respects; canopy closures will fill-in, crown bulk densities will increase, and the number of new trees and shrubs will lower the effective crown base height.

Fuel reduction treatments within the Wildland/Urban interface should reduce expected fire behavior to a level at which a small number of personnel can quickly and effectively control a wildfire. This is beneficial, reducing the possibility that wildfires can get established and reducing the intensity with which wildfires can burn. This further reduces the probability that the demand on emergency response personnel will be exceeded and reduces the threat to life and private property. Wildfires can be controlled with fewer acres burned resulting in less damage to National Forest lands. Also, wildfires burn less severely resulting in less resource damage to each acre burned.

The cumulative effect of this project adds such a fuel treatment to those that lie in the path of the prevailing winds around Flagstaff and its suburbs (Eastside, Ft. Valley Restoration, A-1 Multi-Product, Mars Hill, Airport, Woody Ridge, Kachina Village, Lake Mary Fuel Reduction, Mountainaire, and Skunk Fuel Reduction). The treatments within these projects do not eliminate the chance of a crown fire, but greatly reduce the chance of a crown fire initiating within their bounds.

By treating the Jack Smith Schultz project area, we reduce the risk of a crown fire starting in the project area and spreading as a crown fire through adjacent areas. Also with the two adjacent treatments (Ft. Valley and Eastside) this treatment will further reduce the risk of crown fire spreading to nearby communities at risk and improve this fire adapted ecosystem.

These projects accumulate in the neighborhood of 109,200 acres analyzed and 98,175 acres proposed for treatment. As more acres that are treated in this way these benefits accumulate. As these projects are accomplished we expect the fire hazard rating for all acres analyzed to shift as shown in the following table.

Table 9, Cumulative Change in Fire Hazard Rating

Expected Cumulative Change in Fire Hazard Rating Expressed as a Percentage of All Projects Analyzed To Date					
	Extreme	Very High	High	Moderate	Low
Pre-Treatment	10%	13%	30%	43%	19%
Post-Treatment	3%	4%	11%	30%	66%

The Flagstaff Center anticipates three additional project areas south or west of Flagstaff (Elk Park Meadows, Marshall and Hart Prairie). These project areas would have no effect on the fire behavior or fire hazard of the Jack Smith project area.

Since existing conditions and proposed treatments vary widely across these projects and even within individual projects, it is difficult to summarize the fire effects. It is accurate to state that fire-induced tree mortality across all size classes will be dramatically reduced by these treatments. It is also accurate to state that wildfires occurring in these treated areas will be easier to control and burn less severely with less acreage burned than if the areas were left untreated. These projects combine to form a defensible space for Flagstaff and its surrounding communities.

The Fire Regime would of course remain the same (Fire Regime 1 an open forest maintained by frequent mixed intensity fires and Fire Regime III a mosaic of open forest to mid-seral maintained by mixed severity fires recurring generally 35 to 100), but the condition class would move very close to a Condition Class I, where vegetation composition, structure, and fuels are similar to those of the natural regime and do not predispose the system to risk of loss of key ecosystem components. A wildfire occurring under post-treatment conditions would be characteristic of the historic fire regime behavior, severity, and patterns.

Transportation System
A direct effect of road closures on 27.9 miles, and road obliteration on 38 miles would be that the amount of human caused fires would potentially decrease, whereas an indirect effect would be access for fire fighting apparatus will be limited in the project area and could potentially delay the response times and weaken initial attack actions to both human and lightning caused fires.

Air Quality

Introduction

The prevailing winds for this project area are out of the southwest. However, as fronts pass winds can arrive from any compass direction for a period ranging from a few hours to 3 days. Atmospheric inversions can prevent smoke from dispersing. Within the project area inversions occur between October and December more than at other times of the year. Stagnant atmospheric conditions result from low mixing heights and light transport winds. These conditions when they occur, may last from 12 hours to 7 days (Arizona Department of Environmental Quality, Fort Collins Weather Database).

Regulatory Framework

Smoke from prescribed fire must meet federal, state, and local air quality regulations. The basic framework for controlling air pollutants in the United States is mandated by the 1970 Clean Air Act (CAA), as amended in 1999 and 1990. The EPA has established National Ambient Air Quality Standards (NAAQS) for specific pollutants emitted in significant quantities throughout the country that may be a danger to public health and welfare.

All forest burning activities are regulated and administered by Article 15, Forest and Range Management Burn Rules (10/8/96). The Arizona Department of Environmental Quality (ADEQ) models emissions/pollutants from all prescribed burning within the state. Any prescribed burn planned by the Forest Service must be approved by ADEQ on a daily basis. ADEQ will not allow more acres burned per day, per air shed, than is acceptable with current air quality forecasts. The Forest Service burn boss is responsible for monitoring smoke plume trajectories to assure impacts are within predicted values.

The Forest Service burn boss will make changes as needed when unpredicted weather threatens stronger impacts.

Analysis Methods

Assumptions

The Jack Smith Schultz project area is in the Little Colorado River air shed. The communities of Doney Park/Timberline are east of the project. The community of Flagstaff is located immediately south of the project. Other suburbs of Flagstaff are within 10 miles of the project. There is a high level of recreation activity, especially in the summer months, within the vicinity of the analysis area.

Models

The Fuel Management Analyst (version 3+) was used to model the amount of slash generated for this analysis. The Simple Approach Smoke Estimation Model (SASEM) version 4.0 was used to model the amount of emissions from prescribed burning as well as from wildfire occurrence. The Arizona department of Environmental Quality directs that the SASEM model be used for this purpose.

Methodologies used

Brown's Transect Dead and Down Fuel Inventories were taken to determine dead fuel loading in most sites. In some cases, the Photo Series for Quantifying Forest Residues in the Southwestern Region was used to estimate dead and down fuel loading. Data was collected in 2005 and 2006 by fuels crews. Fire regimes and condition classes were assessed as well during the field surveys for this project.

Existing Conditions

Air quality surrounding the project area is generally good. However, smoke from wood-burning stoves and haze from automobile traffic can be seen at times during the winter months. Prescribed burning from other fuel treatment projects generates emissions that must be balanced with the air mass' ability to disperse emissions on any given day.

Direct and Indirect Effects

No Action

No direct effects would occur since pile burning or prescribed burning would not occur. However, emissions from a wildfire occurring within the project area have been modeled. The amount of fuel consumed and the smoke generated by a wildfire occurring under the no action alternative would be greater than that under the action alternative. The resulting smoke would spread wider and farther than under prescribed burning. Nighttime smoke would reach farther and impact the nearby communities more severely. Smoke would exceed air quality standards in both volume and duration.

The current fuel and vegetative conditions would generate severe fire effects on many parts of the project area. Even after a wildfire was extinguished there would be bare soil areas that when exposed to wind would continue to produce air pollutants. A wildfire occurring within the project area under the weather conditions described in the Fire and Fuels section of this chapter would in places require an indirect attack for successful suppression. This would result in a larger burned area with more emissions than one occurring after implementing any of the action alternatives.

Common to both Alternatives -

Alternatives 1&2 seek to reduce the fire hazard while retaining as many nutrients on site as possible. It proposes burning the piled thinning slash (8,845 acres), as well as, prescribed burning of the forest floor (9,220 acres in Alternative 1 and 9,364 acres in Alternative 2). A direct effect of each alternative is that smoke from prescribed burning will have short-term impacts on local air quality. These effects come from three sources: 1) pile burning of slash generated from thinning trees, 2) initial prescribed-burning the forest floor in small blocks, and 3) maintenance-burning of the forest floor. Emissions generated by these actions have been modeled for the project area.

Pile-burning is relatively efficient combustion producing fewer emissions than both wildfires (pre-treatment) and initial-entry prescribed-burning. Piles can be burned during rain and snowstorms with excellent smoke dispersion and little diurnal smoke flow into the canyons or basins. Proper pile burning consumes a majority of the piled fuel before atmospheric cooling begins. This leaves little fuel to produce smoke for nighttime subsidence flows.

Some smoke from pile burning may still subside into the neighborhoods in and around the project area. Pile burning adjacent to subdivisions may cause short-term (1-day) smoke impacts to a subdivision. This is a direct effect of Alternatives 1&2. Public notification of burning will take place prior to ignition of all 3 types of prescribed burning.

The initial prescribed-burning of the forest floor produces considerably more emissions than pile-burning, but less than most wildfires burning in the same (pre-treatment) fuel bed. The initial broadcast burning of each block in the project area will generate smoke for as long as 72 hours after ignition. The emissions from implementing would generally meet National and State Ambient Air Quality Standards because we can select the weather conditions under which we burn and control the size of the area burned on any given day. The following table displays modeled volumes.

Table 10, Comparing Emissions from Burning to Wildfire

Comparison of Burn Emissions	Existing Condition Wildfire	Post Treatment Wildfire	Pile Burn	Initial Prescribed Burn	Maintenance Prescribed Burn
Ground Fuel Consumed Tons per Acre	8	2	Not Applicable	7	2
TSP Total Emissions Tons	30	0.3	6	13	3
Air Quality Standards	Exceeded	Unlikely	Unlikely	Rarely Exceeded	No

Common to Both Alternatives

Successive maintenance burns on a given block (initiated to mimic the historic fire regime) will generate far less smoke volume and have virtually no smoke after sunset of ignition day. Hence there would be no nighttime smoke (subsidence flow) impacts from maintenance burning. The emissions from implementing Alternative 1 or 2 would generally meet National and State Ambient Air Quality Standards because we can select the weather conditions under which we burn and control the size of the area burned on any given day. This is a direct effect of Alternative 1 and 2.

The high level of recreation activity that occurs in the summer months is not likely to be impacted by smoke because very little prescribed-burning is conducted during those times. Hunters and other people recreating in the project area in the fall and spring could be impacted by smoke from prescribed-burning. This could last for as long as 72 hours during the initial prescribed-burning, but only 6 hours during the maintenance prescribed-burning.

Smoke plume trajectories indicate that the communities within and adjacent to the project area, Interstate Hwy 40, AZ State Hwy 89, and the Townsend/Winona Road may be impacted by smoke when burning. Short-term air quality degradation and reduced visibility may be experienced in the smoke plume trajectories. After sunset, cooling atmospheric conditions will carry smoke down drainages like water flows. Under

Alternative 1 and 2, these down canyon flows reach the communities around the project area in the early morning hours.

These early morning flows may carry smoke down slope and reduce visibility along, Interstate Hwy 40, AZ State Hwy 89, and the Townsend/Winona Road when blocks adjacent to them are being burned. These portions will be posted with appropriate signs warning motorists of reduced visibility. Ignition of each day's block would be completed in the afternoon, thus limiting the smoke generated after atmospheric cooling begins. Smoke impacts would be much worse should a wildfire occur under modeled weather conditions without the implementation of the proposed action.

As stated, broadcast burning could be conducted without violating air quality regulations.

The reduction in the fuel load and the increased openness of the canopy will allow future broadcast burning under a wider range of weather conditions than the existing conditions. The ability of burn managers to limit undesirable smoke impacts is increased by having a wider range of weather parameters within which to burn. The areas thinned mechanically would allow the widest range of prescribed burning weather and lowest risk of smoke impacts because they result in the most open canopy conditions. The areas thinned by hand would allow the next widest range. Areas receiving burn-only treatments may or may not have an open canopy dependant on their existing condition. This is an indirect effect of both Alternatives.

Cumulative Effects

In analyzing the cumulative effects for air quality for the project, the area contained within the Little Colorado Airshed was considered.

No Action

The natural fire regime for most of the project area is frequent surface fires that generally do not involve much of the tree canopy. These would occur at 3 to 15 year intervals. This is a necessary function of this ecosystem. The natural fire regime for the Pinion/Juniper cover type is a fire recurring generally not more than every 35 years (sometimes more than 100 years) where a mixture of over story replacement and surface fire would be expected under historical conditions.

Most of the project area has not experienced fire in over 70 years. By not burning periodically the fuels have accumulated to an unnatural level contributing to more severe fire effects and smoke impacts when wildfires occur. This is a cumulative effect of vegetative growth, aggressive wildfire suppression, and insufficient prescribed-burning. While these actions minimized suppression costs, resource damage, and protected private property in the short-term, they have contributed to an increasing forest fuel problem.

The Coconino N.F. averages about 400 wildfires a year. Roughly half of these are human-caused with the balance caused by lightning. On average there are 85 days a year in which multiple wildfires start. The vast majority of these fires are stopped at $1/10^{th}$ of an acre. Large destructive fires pull the average-annual-wildfire-acres up to 4,000 acres a year. Smoke from a wildfire occurring under modeled conditions would exceed air

quality standards. As more area is left untreated, smoke from a wildfire occurring under the no action alternative could accumulate with emissions from other wildfires and further exceed air quality standards.

Common to both Alternatives

Although smoke from a wildfire occurring after treatment under Alternative 1&2 would be unlikely to exceed air quality standards by itself, it could combine with the emissions of other wildfires and the accumulation might exceed air quality standards. As stated above, the Coconino N.F. averages 400 wildfires a year and 85 days a year having multiple fire-starts. This cumulative effect is not very likely under Alternatives 1&2 because fuel loading will be reduced by the proposed treatments. This cumulative effect would also be unlikely because after treatment, the wildfires could be controlled at a smaller size, burning fewer acres, and fewer days, thus producing less smoke.

As stated earlier, this project lies within the Little Colorado River air shed. There are many other forest burning projects that may affect this air shed (A-1 Multi-Product, Airport, Apache Maid, Bald Mesa, Blue Ridge, East Clear Creek, Ft. Valley Restoration, Good Enough/Tule, IMAX, Kachina Village, Lake Mary Fuel Reduction, Mars Hill, Mint, Pocket Baker, Ritter, Rocky, Sinks, Skunk Fuel Reduction, Spearmint, Valley, Victorine, and Woody Ridge).

Since ADEQ limits total acres burned per day per air shed, daily emissions from prescribed-burning do not accumulate to exceed air quality standards. The number of days per year in which prescribed burning occurs is likely to increase as projects are implemented, but exceeding air quality standards will not be an effect. Further, these projects combine to reduce future smoke impacts. The following table displays estimates of current forest prescribed-burning with estimated capacity assuming normal weather patterns.

Table 11, Forest's Annual Prescribed Burning and Estimated Capability

Estimation of Current Forest Annual Prescribed Burning with Capability	Initial Prescribed Burning	Est. Burn Days	Maintenance Prescribed Burning	Est. Burn Days	Prescribed Pile Burning	Est. Burn Days
Current Execution	13,000 A.	37 Days	7,000 A.	8 Days	1,700 A.	17 Days
Capability With Typical Weather	17,000 A.	50 Days	11,000 A.	18 Days	8,500 A.	43 Days

Smoke from pile-burning may combine with smoke from wood-burning stoves and automobile smoke on some days when inversions are strongest during the winter.

In sites with more closed canopies, forest floor fuel accumulates more quickly. In sites where canopies are denser, prescribed-burning can only be executed under a narrower window of weather conditions. Denser canopies result in fewer opportunities to burn and this in turn is likely to result in less frequent prescribed-burning of those areas. Fuel accumulates more quickly and is prescribe-burned less often resulting in greater smoke impacts.